In situ contouring technique in the treatment of thoracolumbar fractures

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Abstract Burst fractures typically occur at T12 or L1 and create a sagittal deformity by a compression mechanism. This posttraumatic kyphosis is evaluated preoperatively by measuring the sagittal index of Farcy. Posterior instrumentation using in situ contouring is based on a bilateral insertion of rods which take the shape of the spine first. The rods are placed in a perpendicular position to monoaxial pedicular screws and then bent in situ, which makes the spine follow the movements of the rods. This principle makes it possible to correct the posttraumatic kyphosis at the level of the fractured vertebra and the overlying disk, which will open progressively using a ligamentotaxis mechanism. An additional anterior approach is indicated if the sagittal correction through the disk represents less than 50% compared to the total correction (in other words, if the correction of the traumatic deformity is obtained more in the disk than in the bone (>50%), an additional anterior approach is performed: more through the disk than the vertebral body (>50%). This reliable technique meets the requirements of sagittal posttraumatic kyphosis correction, and provides a solid construct which avoids bracing.

Keywords Burst fracture · Thoracolumbar spine · Posterior instrumentation · In situ contouring technique

Introduction

The thoracolumbar junction is the most frequent zone of spinal fractures [2]. This spinal area acts as a real joint between thoracic kyphosis and lumbar lordosis. It is characterized by the absence of an intrinsic curvature, but the natural trend of this area is to evolve toward kyphosis [5]. Subsequently, burst fractures typically occur at the levels of the T12 and L1 vertebral bodies (Fig. 1). The sagittal deformity caused by a compression mechanism needs to be evaluated carefully to indicate surgical correction. The sagittal index of Farcy et al. [1] describes the deformity resulting from the injured vertebral body and disk above by measuring the angle between the lower endplate of the fractured vertebra and the lower endplate of the overlying vertebra (Fig. 2). At T12–L1 the physiological sagittal index is 0°. At each thoracic level between T1 and T12 this index is characterized by +5° of kyphosis on average. At each lumbar level between L1 and S1 it is characterized by –10° of lordosis on average. The surgical treatment of spinal fractures at the thoracolumbar junction consists of sagittal deformity correction and stable fixation. Complete reduction of the fracture using posterior instrumentation is mandatory to achieve a physiological sagittal index and an adequate balance between thoracic kyphosis and lumbar lordosis. Furthermore, a stable posterior rod construct facilitates quickly mobilizing of the patient without a brace.

Posterior instrumentation using in situ contouring

At our institution, reduction is usually performed using the in situ contouring technique with a posterior approach. From a technical point of view, the principle of in situ

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Fig. 1 Burst fracture of L1 vertebral body with flexion-distraction mechanism and additional fracture of the T12 lamina and spinal process

Fig. 2 Sagittal index with posttraumatic kyphosis (SK in degrees) between lower endplate of fractured vertebra and lower endplate of vertebra above

contouring aims at first making the rod take the shape of the spine and then to make the spine take the shape of the rod that has been previously contoured. A rod is inserted on each side of the spine and contouring is performed bilaterally and simultaneously. While the rods are bent in situ, the spine follows the movements of the rods. This principle makes it possible to correct the posttraumatic kyphosis at the level of the fractured vertebra and the overlying disk, which will open progressively without excessive stress using a ligamentotaxis mechanism (Fig. 3). During the entire in situ bending maneuver, it is necessary to use a screw rod construct which keeps perpendicular in the sagittal plane. Monoaxial pedicular screws are usually

Fig. 3 Reduction maneuver by in situ bending opening the fractured vertebral body and the injured disk above

placed in a parallel position to the superior endplate of the instrumented vertebra. The implants need to keep unlocked in order to allow an axial rotation of the screw around the rod while the rods are manipulated. Polyaxial screws cannot be used because the reduction maneuver would modify the position of the screw itself without correcting the sagittal orientation of the vertebrae. A standard fixation is performed between T9 and L1 for T12 fractures and between T10 and L2 for L1 fractures (Fig. 4). Two screws are placed in each vertebra above and below the fractured level. Screws are generally protected by hooks in order to reduce moments at the upper and lower levels of the screw rod construct. At the superior part of the instrumentation, a pediculo-transverse claw is performed at T9 or T10. At the inferior part, an offset sublaminar hook is placed on the vertebra underlying the fracture under the lamina of L1 or L2. The intraoperative correction of the posttraumatic

Fig. 4 L1 fracture with posterior instrumentation between T10 and L2 and additional intersomatic bone graft between T12 and L1

kyphosis can directly be evaluated using fluoroscopy using the sagittal index. Furthermore, the position of the screws in the sagittal plane represents an indirect marker; the initial convergent position of the screws needs divergent or at least parallel after reduction. The surgery ends with posterior bone grafting which enhances the long-term strength of the spine at the thoracolumbar junction and prevents secondary loss of reduction. Postoperatively, the patient is mobilized and allowed to stand up at day one after surgery without wearing a brace.

We have recently reviewed a series of 70 thoracolumbar fractures using the in situ contouring technique [3]. In this study, the average time of surgery was 100 min (80–240 min), the average blood loss 813 ml (64–2,975 ml) and the average hospital stay was 16 days (5–21 days). Longer hospital stays were often due to multiple injuries such as polytrauma. In the studied cohort, 71% of the patients who underwent surgery returned to their previous employment within 7 months. The average sagittal index was 16.9° preoperatively and decreased to 1.6° postoperatively.

Additional anterior fusion

After posterior instrumentation and fusion, the anterior reduction at the level of the fractured superior endplate, the vertebral body and the overlying disk is evaluated on postoperative radiographs and computed tomography. An additional anterior approach is indicated if the sagittal correction through the endplate and the disk represents less than 50% compared to the total correction. Such an osseous defect is unstable at long-term and needs to be filled using a bone graft from the iliac crest. Cages with a bone substitute or additional bone morphogenic proteins may alternatively be used. A small (~5 cm) selective video-assisted right or left thoracic approach is used for the intersomatic fusion at the T11–T12 or T12–L1 levels. This second operation is usually performed within 6 weeks after posterior instrumentation, which reduces the risk of secondary anterior height loss compared to cases, where anterior fusion is delayed by more than 3 months.

In our study, 38 out of 70 patients (54%) underwent an additional anterior fusion. After more than 1 year, final measurements of the sagittal index showed an average loss of height of 5.2° in patients who underwent a simple posterior fusion. The average loss of height was 1.2° in patients with anterior and posterior fusion and significantly lower compared to simple posterior fusion ($P = 0.002$).

Conclusion

The presented T9–L1 or T10–L2 posterior standard instrumentation using the in situ contouring technique meets the requirements of sagittal posttraumatic kyphosis correction, and provides a solid construct which avoids bracing. It has not been proved that the same quality of reduction can be obtained by a single anterior approach or that a single anterior fixation is solid enough to avoid bracing [4]. The use of an additional intersomatic bone graft enhances long-term stability of the initial reduction and fusion in cases where the osseous defect of the superior endplate and fractured vertebral body remains significant.

Conflict of interest statement None of the authors has any potential conflict of interest.

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